STRUCTURED RISK MANAGEMENT PROGRAMS

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INTRODUCTION

There is every reason to believe that mankind has always had to cope with accidents and disasters. History contains many references to both natural and man caused disasters. Many of the earliest man-caused disasters were fires which often had devastating consequences. The experiences gained from these catastrophic fires were painful but useful in that they contributed to improved methods of prevention and fire fighting. Similarly our experience with chemical accidents can and should lead to safer operations. However, this process will be greatly influenced by the way in which we react to accidents.

Risk management in the chemical and process industries encompasses several distinct but related phases. These include worker safety, environmental impacts, and community impacts. Although this may seem elementary, for many years safety to the U.S. chemical industry basically meant worker safety. Worker safety is only one aspect of plant safety. The accidents which today may expose a company or community to the greatest risk may have little relationship to the traditional tenets of worker safety. Vapor clouds can often pass right over the plant and such releases may have little relationship to typical worker injuries.

The concept of chemical risk is now changing primarily as a result of several major chemical accidents resulting in significant loss of life and property and a greater public awareness of exposure to both acute and chronic chemical risk. The best known and clearly the incident with the greatest loss of life was the Bhopal release in late 1984. Although there have certainly been other serious chemical and gas accidents (Mexico City, Seveso, Italy, Sandoz's Basel plant) the magnitude and suddenness of Bhopal shocked people all over the world. That the disaster emanated from a manmade source has distinguished it from numerous equally serious natural disasters and proved a continuing fascination to those concerned about the impacts of modern technology.

During the last few years many of us have become more actively involved with chemical and process plant safety issues. Involvement with a number of different safety related studies, discussions with numerous industry professionals and governmental officials, participation at seminars and conferences and close inspection of the literature have helped give us a perspective on plant safety and risk management. Today we want to share these observations and personal opinions with you and thereby contribute in a small way to the development of a necessary consensus on chemical risk management. Because of our greater involvement with safety-related activities and initiatives in the U.S., our remarks will relate most closely to the U.S. situation. However, we believe that there will be numerous aspects

of our observations and suggested approaches that will have relevance internationally.

GENERAL OBSERVATIONS

The increased public focus on chemical industry operations comes during a period of economic upheaval for the world wide chemical industry. Economic development throughout the world, rising international trade imbalances and consequent currency exchange rate fluctuations have contributed to the erosion of foreign markets for U.S. producers as well as the development of fierce competition from both U.S. and international producers in the U.S. market. There has been a trend for traditional raw materials suppliers to develop their own processing capabilities and to become exporters of intermediates or products. These factors together with aging physical plants in many developed countries including the U.S. have led companies to reduce their exposure in areas of low profit margins such as commodity chemicals. Aging plants are being shut down rather than modernized. Producers in the U.S. have turned to narrower specialty areas in attempts to maintain economic viability.

A decision to devote more resources to plant safety and loss prevention efforts in such an unstable economic climate is difficult. Immediate economic benefits are not obvious although added costs will be seen quickly. The driving force for development of a process plant safety program will not be purely economic.

Nevertheless, there are factors which are driving the U.S. chemical industry to devote more efforts to these areas:

- Continuing public attention and negative media coverage create an atmosphere which leads to pressure for additional regulation of the industry. Recent domestic U.S. regulatory experience (e.g., Resource Conservation and Recovery Act or the nuclear industry) shows a tendency toward becoming more and more prescriptive and bureaucratic. Innovation and improvements become more difficult to achieve and the permitting process becomes a seemingly endless activity. It is not difficult to foresee a climate in which decisions to build new facilities in less regulated areas are easily made. Of course, since safety is an international issue, this option may be considerably curtailed in the future. Projects in which World Bank participation in financing is involved are already subject to formal safety studies.

- Increasing costs and, in some cases, unavailability of liability insurance is a reality. Companies in the industry have formed groups to provide insurance to themselves. Deductible and self insurance amounts have grown larger and larger. The increasing tendency to go to court (especially in the U.S.) and the public's heightened awareness of a "chemical problem", will further increase costs.

- Finally, there is a common human desire to avoid disaster and protect life and our shared environment. Although economic and

institutional realities often temper this motivation, it is nevertheless still applicable.

These factors have indeed led to movement in the industry. In the U.S., cooperative efforts through industry and professional associations, such as Air Pollution Control Association (APCA), American Institute of Chemical Engineers (AIChE), through its new Center for Chemical Process Safety, American Petroleum Institute (API), and Chemical Manufacturers Association (CMA), have accelerated. New initiatives have been forthcoming from these groups, and from new organizations such as the National Institute for Chemical Studies, a voluntary action coalition of government, industry, and the public sector based in West Virginia's Kanawha Valley. For example, CMA's CAER (Community Awareness and Emergency Response) program and its expanded CHEMTREC (Chemical Transportation Emergency Center) are designed to improve public and industry cooperation while the National Institute for Chemical Studies has sponsored major meetings involving people from all segments of our society. The many skills and techniques required for risk management programs exist in the chemical and other industries and can be mustered when needed. Probabilistic risk assessment techniques have been developed and are routinely applied in the aerospace and nuclear industries and are now being widely adopted in the chemical industry.

The U.S. nuclear industry provides an apt example of successful initiative in the form of INPO (Institute for Nuclear Power Operation). INPO is a cooperative organization which was formed by nuclear utilities. It is strongly financed (operating budget of more than $6,000,000), staffed with recognized professionals and authoritative. Its purpose is to act as a clearinghouse for information and to improve nuclear plant safety by fostering and providing a broad based system of ongoing data accumulation and analysis leading to continuing upgrading of equipment, systems and procedures. There has been a perceptible reversal in the growth of the size of the U.S. Nuclear Regulatory Commission (NRC) staff and in the number of rules and regulations promulgated by the NRC since INPO has become functional. An organization with the potential to acquire the clout of INPO has not yet appeared in the chemical industry. The basic structure, diversity, competitive nature and international status of the chemical industry are different and undoubtedly make the emergence of such an association more difficult.

A second area of movement that is visible is in the area of individual corporate risk management programs. A reassessment of corporate programs is underway in an increasing number of companies both large and small. In certain cases, this is a result of individual company decisions to proactively reduce the risks of doing business, while in some cases, it is more a result of increasing regulatory pressures.

These developments in the industry itself are impacted by numerous external factors. Two of the most important factors, the treatment by the public media and governmental regulatory activities, are discussed in the following sections.

EFFECTS OF MEDIA COVERAGE

Certainly the reaction to Bhopal and other plant accidents is different now than it would have been in an earlier age. The developments in electronics and global communications have enabled the media to bring the horrors of the Bhopal accident to our immediate attention. Environmental groups and others concerned with the impacts of modern technology have already done much to cause the public to be distrustful of industry and technology. Furthermore, the timing of Bhopal itself seems to have come at a time when environmental groups and the media especially in the U.S. were looking for a new issue. The total lack of any newly started nuclear power projects in the U.S. has reduced the media's preoccupations with nuclear power while the similarity between chemical plant accidents and hazardous waste problems has tended to intensify the interest in anything chemical. Indeed similarities between the invisible nature of certain toxic atmospheric releases and equally invisible radiation may aggravate the situation. Newspaper surveys performed after Bhopal but before Chernobyl indicated that the number of news articles dealing with chemical effects exceeded the number of articles dealing with nuclear power.

This intense media barrage is really autocatalytic and leads to the extensive coverage and magnifications of even very minor accidents. All of which over time tends to create in the public mind an impression that the situation is rapidly worsening when in reality it may only be the coverage that is rapidly increasing. The result can be to make what is a real but manageable problem, into one that is perceived by the public as a crisis requiring draconian measures.

In this type of an environment anyone associated with the chemical industry must be very careful in their responses or public utterances. Too casual or not fully supported assurances of safety may be immediately comforting but can later result in a devastating backfire. The mid-1985 accident at the Union Carbide pesticide plant in Institute, West Virginia illustrates this fact. Although there were no obvious long term or extremely serious health impacts from this accident, the mere fact that it occurred after Union Carbide had publicly indicated that Bhopal type disasters were almost inconceivable in their domestic plants was embarrassing and extremely damaging to the public confidence. The incident illustrates that safety and risk management is indeed an international issue.

Public opinion will ultimately determine the extent of governmental regulation of the U.S. Chemical industry. Increased regulation is probably inevitable. Many in the chemical industry feel that a certain degree of regulation may even be beneficial but only if applied fairly and in the mood of cooperation rather than in an adversarial manner. The ultimate fairness and intelligence of the media will be influential in the shaping of this public opinion. The process industries must learn to deal effectively with the media and this will require a mixture of honesty, patience, and education.

GOVERNMENT INITIATIVES

In the U.S., government initiatives have been slow in developing. This may have been a result of a realization of the complexity of the chemical and process industries, their importance to the nation and the economic difficulties facing the United States chemical industry. On the other hand, the slowness of governmental response could represent a real lack of understanding of what to do and how to finance it. The U.S. Environmental Protection Agency (EPA) has shown reluctance to leap in with major new safety programs and is no doubt acutely aware of its lack of extensive chemical safety expertise.

At the date of this writing federal legislative activity has centered on right-to-know and emergency preparation legislation designed to identify potential chemical hazards to the public and to help the public prepare for accidents. The difficulty here is that the public will generally lack the technical knowledge required to evaluate these data and make informed judgements. It is quite probable that right-to-know legislation only represents the beginning of a more comprehensive legislative program. The result of this initial federal activity has been the passage of Title III of the Superfund Amendments and Reauthorization Act known as the Emergency Planning and Community Right-to-Know Act of 1986. This act establishes data reporting requirements and a structure and schedule for statewide emergency planning covering all facilities handling extremely toxic materials. Key deadlines in this act occur throughout 1987 and 1988.

EPA's major contribution to date has been to develop and publish a list of nearly 400 acutely toxic chemicals along with guidelines designed to instruct communities on how to inform themselves about chemical risks and how to initiate emergency preparedness programs. The Emergency Planning and Right-To-Know Act have really encoded these EPA activities and given them the force of law.

Most state activities have also dealt with right-to-know legislation or emergency planning requirements. The most comprehensive state law has been enacted in New Jersey which contains one of the heaviest concentrations of process facilities in the U.S. The bill is entitled the "Toxic Catastrophe Prevention Act" or Baer Bill after its legislative sponsor. The bill initially addressed only eleven "extraordinary hazardous" chemicals but included a provision for expansion of this list by mid-1987, which is now being implemented. Nearly 100 additional chemicals are to be covered. The ultimate goal of the bill is to ensure that every company handling the specified compounds has an approved Risk Management Program. In the absence of an approved program the bill requires the performance of an accident risk assessment by an independent third party selected by the New Jersey Department of Environmental Protection. Recently proposed implementing regulations have spelled out the elements of an acceptable risk management program. Key elements would cover procedures, training, equipment, maintenance, testing, emergency responses, mitigation techniques, hazard identification, and hazard analyses. The program proposed by New Jersey is extemely comprehensive and prescriptive and will require major expenditures and commitments by New Jersey industry. Serious civil and criminal penalties are proposed and more than 900 facilities will be impacted.

New Jersey's program has received considerable attention from other state environmental agencies. Other states are proceeding very cautiously. California has recently enacted a similar risk management bill calling for registration of acutely hazardous materials and the preparation of a Risk Management and Prevention Plan. The effectiveness with which New Jersey and California implement these acts will have considerable impact on the shaping of both state and national regulatory programs.

RISK MANAGEMENT

Our observations convince us that we have passed the point of no return and that industry must take action if it is to control its own destiny. We have briefly mentioned the two pronged approach - at the industry-wide level in the form of an INPO-like organization and at the individual company level in the form of a risk management program.

The emergence of risk management programs while voluntary, has been partially motivated in some cases by regulatory requirements or by a desire to stave off additional regulatory action. The developing framework often incorporates and integrates elements of practices which had previously been established.

What are the characteristics that a successful risk management plan should have? We would propose:

1. It must be credible
2. It must be organized and thorough
3. It must be understandable and address the concerns of the public
4. It must be do-able and economical
5. It must be based on existing technology with flexibility to adapt to advances as they occur
6. It must be publicized

The first three points are closely related and reinforce one another. The clearer it can be made that the program is comprehensive and open, the more support it will generate from interested parties. This aspect of the program must go beyond the requirements of "Right-To-Know" laws in so far as it will do more than identify hazardous materials; it must also identify plausible potential scenarios for accidental releases, the consequences of such releases and the mitigative actions taken or planned. This will pose a burden on companies which are using proprietary technology in their processing operations. It will require that documentation which is made available to the public be carefully screened to present information in a manner which is forthcoming and avoids the appearance of being a cover-up.

The key elements which must be present in a Risk Management Program are:

- Hazard Identification
- Consequence Analysis
- Control or Treatment Responses

- Procedures - Operating
  - Maintenance
  - Testing and Inspection
  - Change Control
- Training
- Emergency Planning
- Accident Investigation
- Audits

A careful examination of what is meant by each of these elements follows:

Hazard Identification:

Mechanisms must be established to ensure rigorous comprehensive review of the material handled at the facility, the equipment used and the operations and procedures utilized. The results of this review should be documented and saved for future reference and use, for example, when a change is being made in the process or operation. Typical techniques which are applicable include use of checklists, HAZOP studies, fault tree analysis, or Failure Modes and Effects Analysis.

All of these procedures have their advantages and disadvantages. There is no one universally correct or preferable choice of methodologies. The selection of a hazard identification technique for any particular process depends on a number of factors. Obviously, the stage of development of the process is critical. Different methodologies could be used during the conceptual design, construction or operating phases of a process. Screening and ranking methodologies are most appropriate in the early stages of process development. Typical approaches include Preliminary Hazard Analyses or the use of hazard checklists or indices such as Dow-Mond. These are strictly experience based approaches and help to establish relative levels of hazardousness for a process.

More exacting and methodical methods such as Failure Modes and Effects Analysis, What If Analyses, or Hazard and Operability studies allow for a more structured approach to hazard identification as well as facilitating the use of creativity and imagination. These techniques are most appropriately performed in the latter stage of design or during operation of a process. They depend on more developed information and documents such as Piping and Instrumentation Drawings. These approaches are more likely to uncover unusual or unexpected events that although low in probability of occurrence have potentially severe consequences. Their use is also more manpower intensive and requires the expenditure of greater time and money.

Mathematical and probability techniques such as Fault Tree or Event Tree Analyses can be very forceful tools but require even more expertise and resources. These probabilistic methods are particularly good for reviewing complex processes and interacting system. Where a sufficient data base exists they can lend to quantitative estimates of the frequency of certain accidents.

The important thing from the programmatic standpoint is to ensure that appropriate methods of hazard identification are applied to new processes

and modified projects and on some periodic basis to operating processes. Furthermore, the choice of methodologies should follow from a considered evaluation of all relevant factors.

Both the Chemical Manufacturers Association and the American Institute of Chemical Engineer's Center for Chemical and Process Safety have prepared extensive guidelines to help in the selection of an appropriate hazard identification technique. Internationally, the World Bank has also prepared a manual to assist in the performance of hazard evaluations.

Consequence Analysis:

The consequences of undesired events identified in hazard evaluation procedures must also be determined. With the exception of rough screening analyses, consequence analysis is site specific; it must consider the type of hazard involved, site location, population density and prevailing weather patterns. The consequences to be determined will include both health and economic effects. For explosions, pressure wave radii can be calculated; for fires, fireball radii and thermal radiation values vs. distance; for toxic releases, airborne concentrations as a function of distance or potential drinking water concentrations.

Consequence analysis is an important part of a risk management program because risk really is a function of the probability of occurrence of an event and the consequences of the event. Therefore, the management of risk associated with an identified hazard requires the best possible understanding of the consequences of the particular hazard. Thus, for all but the most obviously serious hazards or those that have easy or relatively inexpensive fixes good consequence analysis is nearly as important as identifying the hazard.

Treatment of this subject is not within the scope of this paper but it is worth noting that good accurate modeling or simulation in a realistic fashion is very difficult. Atmospheric dispersion is not readily duplicated in a laboratory and is even more difficult to reduce to analytical terms. Efforts in this direction will be increased as the magnitude of both risks and mitigation costs are better understood.

Control or Treatment:

Means used to control potential releases or their consequences to the environment must be identified. These could include provision for scrubbing systems to neutralize or remove hazardous components, flare systems or incinerators to destroy hazardous compounds or even secondary containment devices to temporarily hold the hazardous material until it is further processed prior to release. Numerous guides and texts exist that can aid the engineer in the selection of appropriate equipment or process changes. The principles involved are similar to those encountered in the development and operation of processes. Indeed the optimum solution often involves process modification rather than add-on hardware. The real importance of singling out this step is to assure that appropriate action is taken on every identified hazard.

Procedures:

The implementing procedures must be consistent with plant safety programs. Operating procedures must address issues revealed in the hazard identification step. Maintenance, testing, and inspection procedures must address hardware items which have been determined to be critical from a safety viewpoint. A preventive maintenance system which identifies trends in equipment failures should be in place to provide feed forward data. Proper procedures may be the most economical and in some cases the only practical way of managing a particular risk.

Change Control is an area which cannot be over emphasized in a risk management program. It must control changes no matter how seemingly minor, it must maintain documentation and drawings in a current condition and it must provide for a hazard analysis as part of any change (documentation prepared in the Hazard Identification step is useful here). To be successful this cannot be just a paper program. It must be truly a controlled process and can only work with complete management commitment.

Training:

A recent study of accidents in petroleum processing and storage facilities has revealed that roughly two-thirds of the accidents were due to human error rather than to hardware failure or design deficiencies. The best procedures are worthless paper if people are not trained to understand their intent and proper implementation. Periodic refresher training must be carried on as operators or procedures change. Again these cannot be mere rubber stamp courses; serious weight must be given to these courses and they must be integrated into a coordinated program in an atmosphere of corporate commitment.

Emergency Planning:

Despite the best efforts of plant designers, equipment suppliers and operators, zero risk is an unattainable goal and accidents will occur. Results of the consequence analysis can be used to prepare contingency plans which must be in place. Personnel must be trained in what actions they are required to take in the occurrence of pre-determined scenarios. Channels of communication and coordination with local governmental and voluntary agencies must be established. CMA and the EPA are both quite active in this area and have prepared worthwhile guidelines for preparation of effective emergency plans. The Emergency Planning and Community Right-to-Know Act of 1986 recently passed in the U.S. now requires nearly all companies to participate in the preparation, maintenance, and potential implementation of comprehensive emergency plans.

Accident Investigation:

The old saw that experience is the best teacher although trite is often true. However, to be an effective teacher, we must obtain accurate and unbiased feedback from experience. Unfortunately, an accident tends to make the people involved very defensive and fearful. An effective accident investigation procedure must be perceived as being a learning tool for determination of possible preventive measures rather than as a search for a

scapegoat. Unfortunately, human nature being what is is, this is easy to accept in theory and often very difficult to actually put into practice. Nevertheless for accident or near accident investigation to work effectively, management must practice what they preach.

Audits:

As in any program, periodic checks are required to ascertain the effectiveness of the program as well as the degree of compliance. A management which pays lip service to safety yet concentrates its resources on production, is not doing itself or the industry any favors. Audits are a key source of feedback to management as well as a sign to personnel that the risk management program is to be taken seriously.

Audit programs can be administered in a number of ways. Again, there is not necessarily any one correct way. Programs can be administered from central audit departments or groups or run by ad hoc committees which utilize personnel from other plants or groups. Outside consultants can be used entirely or in part or some combination of all of the above can be used.

CONCLUSION

In summary then, individual chemical and process companies must take safety initiatives in-house as well as out-of-house collectively through one or two independent industry-wide groups. The overall external effort should be coordinated by only a few organizations to avoid dilution of what needs to be a substantial and well financed program. INPO would appear to be an excellent model for this type of industry group. There is little doubt in our minds that the development of an active external organization with both independence and some meaningful level of authority is required to reverse the loss of public confidence and avoid the creation of a cumbersome and stifling new regulatory program.

All responsible companies must adopt, implement and eventually institutionalize an effective corporate risk management program. No one should realistically expect any long term resolution of either the preceived or real problem of chemical risks to come from anywhere but within the industry. The industry can utilize analysis techniques developed in other industries and establish organizations modeled on those used successfully in other fields, but must eventually adopt these mechanisms to fit the chemical industry.

To proceed with both of these simultaneous initiatives, the industry has to achieve a real and substantial concensus. The costs incurred through application of a comprehensive risk management program must be accepted as a necessary cost of doing business and serve as an incentive to design processes and plants that are inherently safer. It is entirely possible that the careful adherence to safety principles may, in the long term, reduce wastes and improve productivity. The alternative to concerted industry efforts in the U.S. is almost certainly going to be an enactment of an extensive and inefficient regulatory program.